BNL CNG Release Investigation

NFS14 Workshop

May 6, 2014

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Brookhaven National Laboratory

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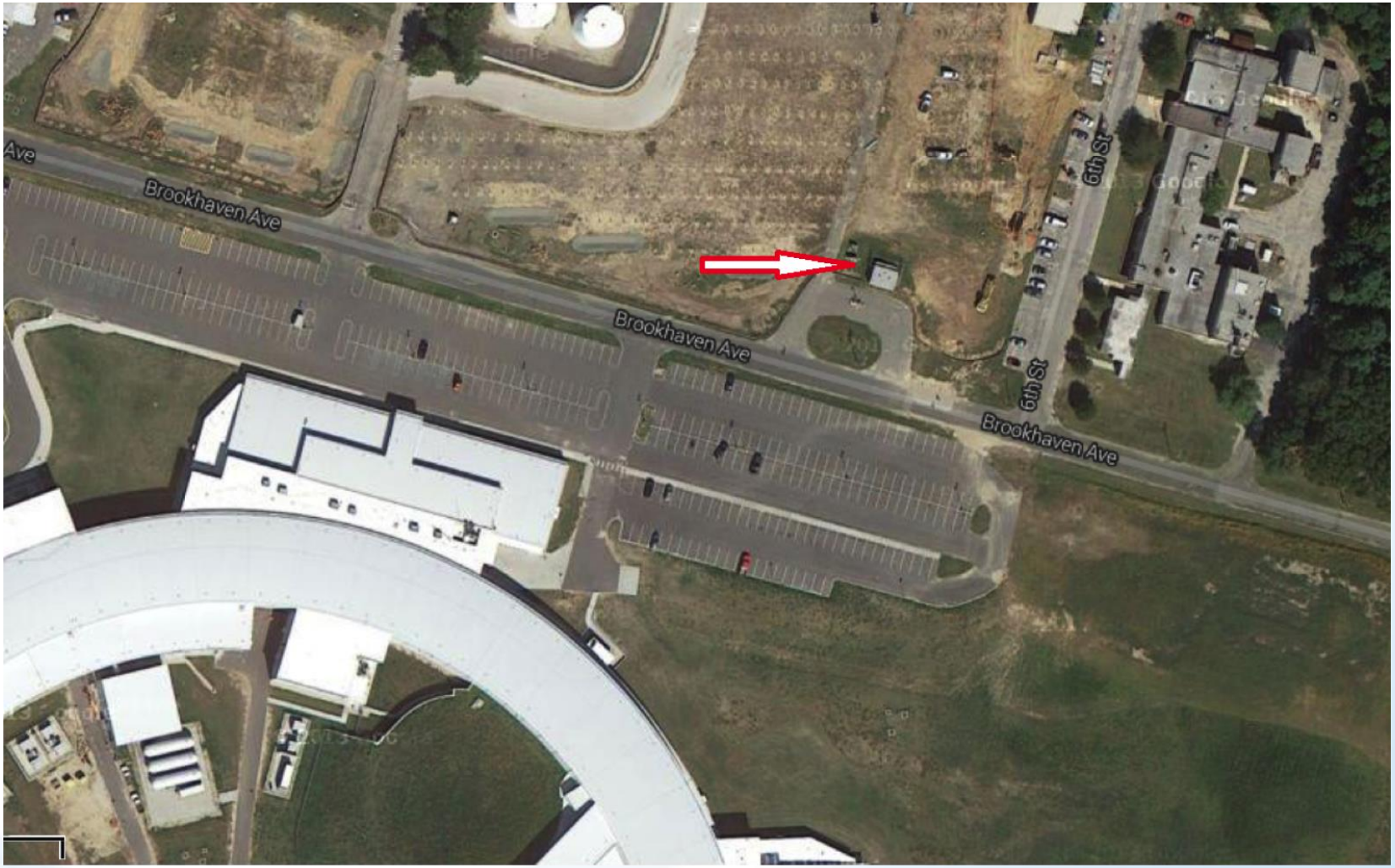
January 6, 2014 ~7:57 AM
Looking East on Brookhaven Ave.

The Event

- Monday January 6th, 2014 at 07:57 hrs.
- Call received on x2222 for a vapor cloud release at Bldg. 522
- Fire-Rescue and Police responded
- Area cordoned off
- Command Post established in B741 parking lot
- 08:10 hrs Operational Emergency declared, Request to open the EOC was made
- Shelter-in-Place ordered for zones 5 & 12
- Notifications to DOE made from the field electronically
- Emergency Stop Buttons activated
- Natural gas supply valves isolated
- Compressed cylinder pressure relief valve (PRV) isolation valves locks cut and closed (middle and bottom tank pressure relief valves still operating)
- Area gas monitor surveys conducted in B526, B528, B610
- Shelter-in-Place rescinded for zones 5 & 12
- Scene secured for Investigation
- LOTO for electric and main gas line established

The Investigation - First 48 Hours

- Preliminary briefing from EOC team
- Investigation team members identified
- Initial scene survey
- Photo documentation
- Participant interviews
- Initial data gathering
- ALD for F&O schedules weekly committee briefings with management & DOE.
- Developing plan of action to temporary refuel CNG vehicles off site

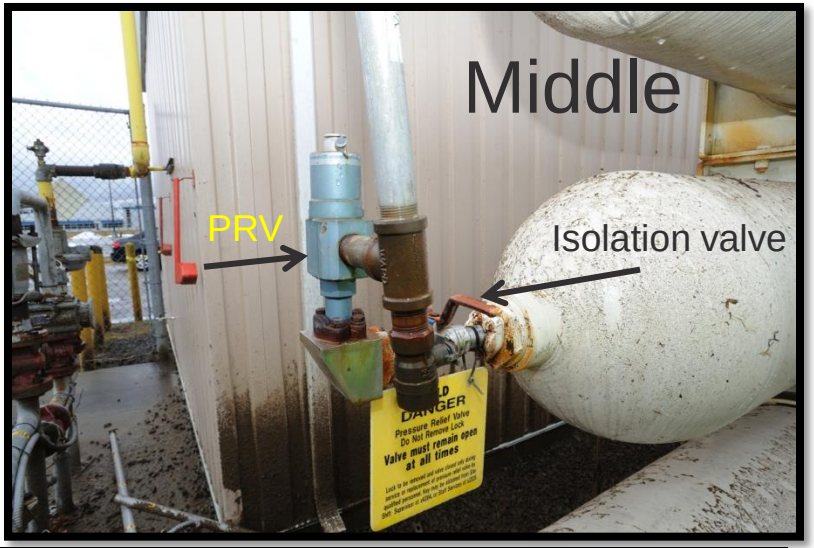

Brookhaven Ave
Brookhaven Ave
Brookhaven Ave
6th St
6th St

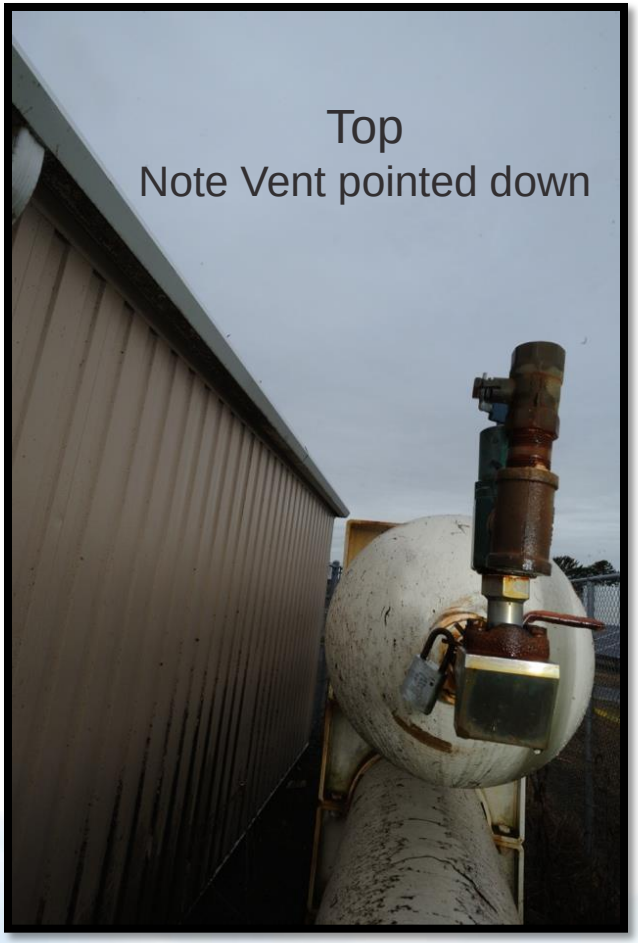
- Front View - Wide

- Right (East) side

- Rear (North) side

Pressure Relief Valves after Incident

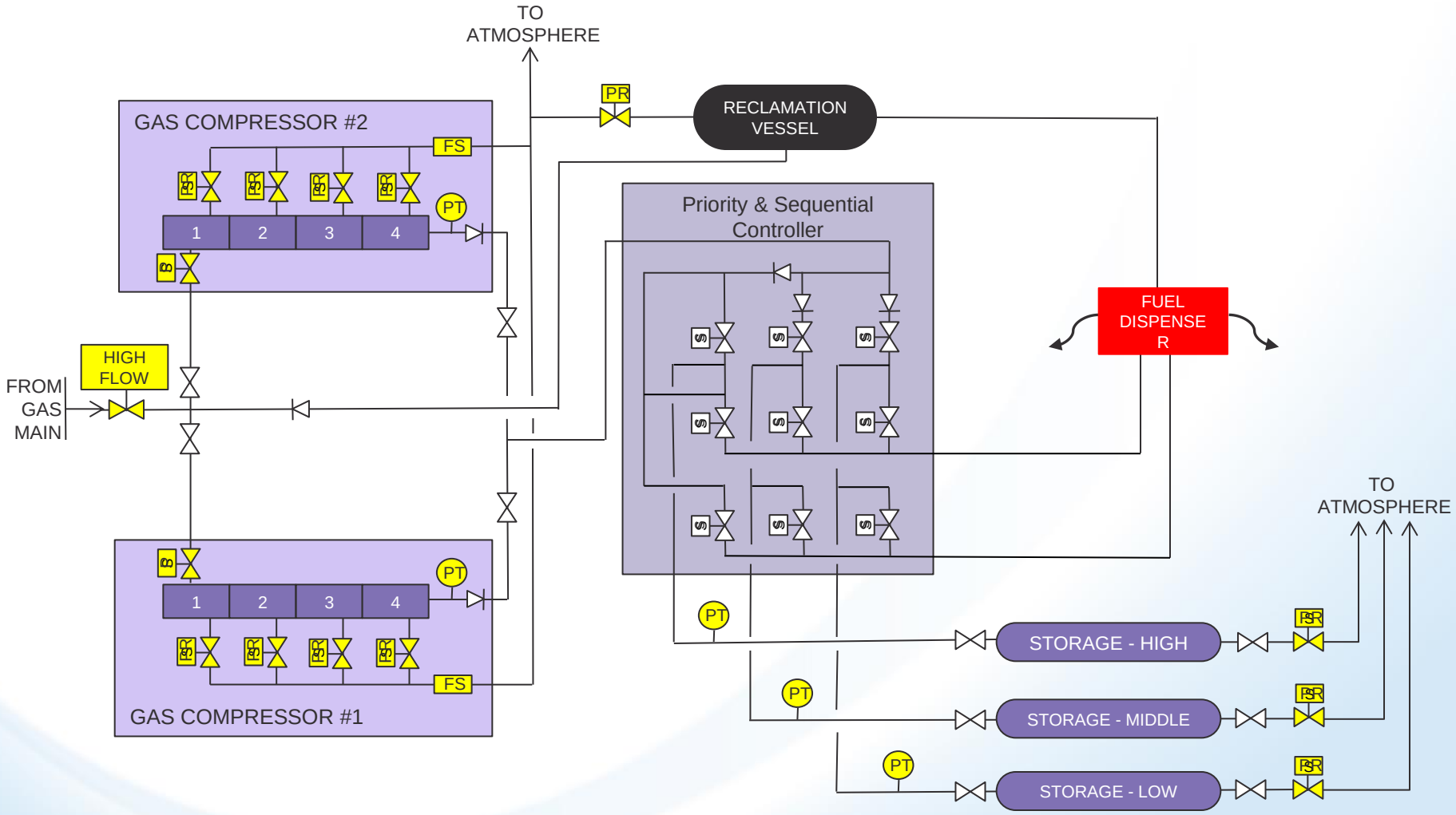




Major Issues of the system to be determined

- Why the cylinders reached 5500 psi relief valve blow off settings
- Did the control system operate as designed prior to release.
- Did the pressure relief system operate as designed
- Why the 5500 psi relief valves acted as they did after operation

Schematic of CNG System

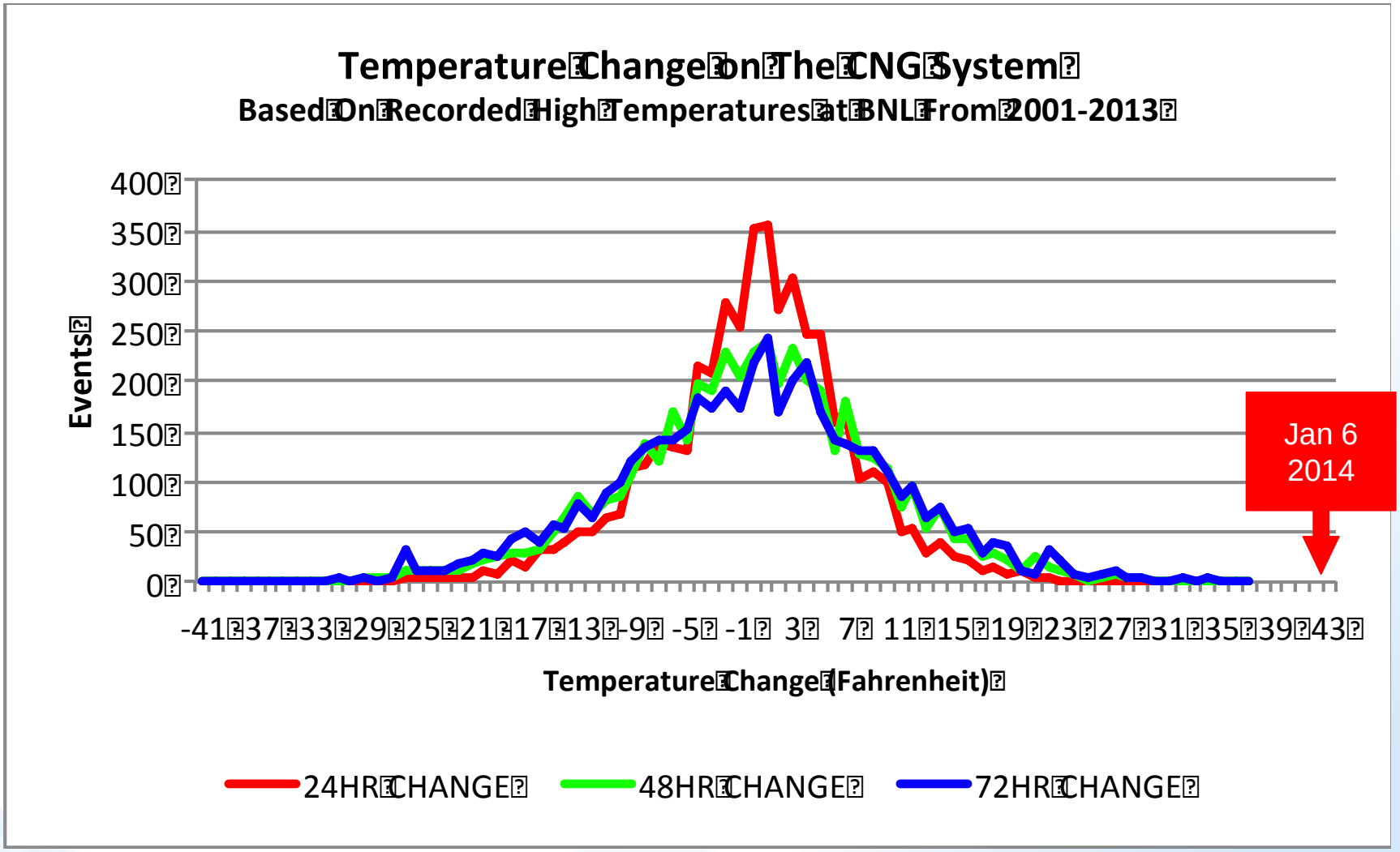


Facts of the CNG Station Prior to Release

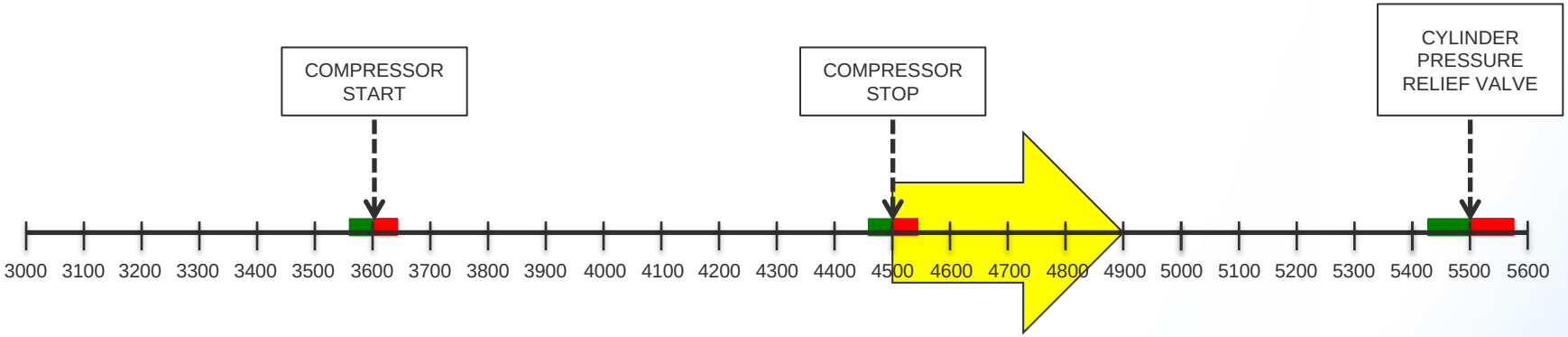
1. Designed & Built in 2001 by Air & Gas Technologies (AGT) to NFPA 52 (1998).
2. Independent Review of the system by qualified CNG Installer
3. AGT maintains the system on a monthly basis.
4. Designed to support 100 vehicles (Vehicle fill pressure: 3,600 psi).
5. Presently 61 Vehicles on site. Newest vehicles(3) are 9 years old. Most vehicles approaching end of life. GSA fleet replacement underway.
6. Vehicle Fueling is done during business hours Monday to Friday.
7. Compressors start when pressure drops to 3,800 psi
8. Compressors stops when pressure reaches 4,500 psi
9. Each of the three cylinders has a pressure relief valve calibrated to operate at 5,500 psi
10. System built with Two Compressors. Only one compressor in service at time of release.
11. Based on energy usage, the Compressor last operated @ 13:00 hrs. on Friday January 3, 2014.
12. Temperature was 14°F @ 13:00 hrs.

CNG Station at time of Release

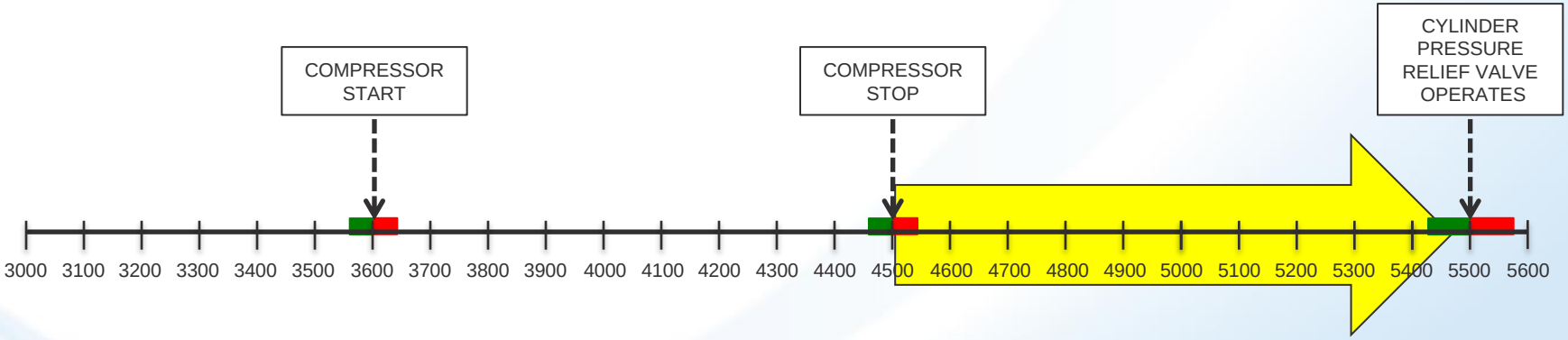
- Temperature: 56°° F ;
- Wind from the South 10-12 MPH with gusts to 20 MPH
- All three Pressure Relief Valves operated. Only top relief valve appeared to reseat.
- Compressor appears to have been operating during the event after system dropped in pressure.
- Estimated release between 700 to 1,000 lbs. Below EPA reporting threshold (10,000 lbs.)


Temperature Change on The CNG System
Based On Recorded High Temperatures at BNL From 2001-2013
Events
400
350
300
250
200
150
100
50
0
-41 -37 -33 -29 -25 -21 -17 -13 -9 -5 -1 3 7 11 15 19 23 27 31 35 39 43
Temperature Change (Fahrenheit)
Jan 6 2014
24HR CHANGE
48HR CHANGE
72HR CHANGE

Thermal Expansion
Effect of 42 Degree Increase on the CNG Station

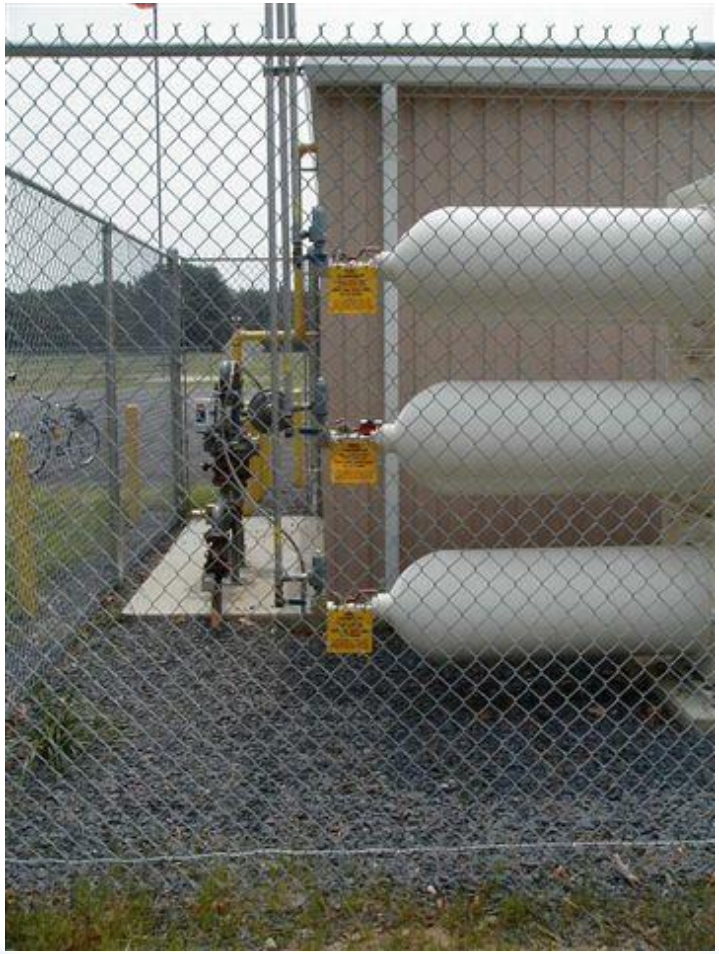


CNG ACTING AS A IDEAL GAS



CNG ACTING AS A REAL GAS

Pressure Relief Valve Vent Design

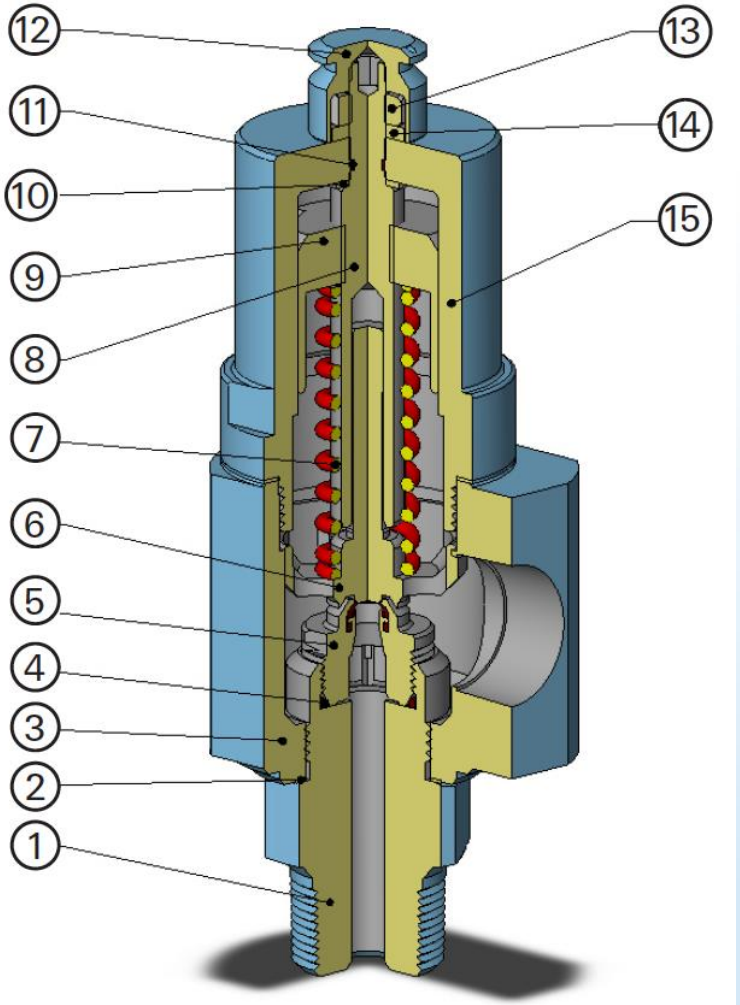


2001 DESIGN

2014 CURRENT

Pressure Relief Valve

1. Calibrated less than 3 years ago
   - Set at 5,500 psig to open
   - Re-seat at 4% (~ 5,300 psig)
   - Certificates provided
2. Visual Inspection shows damage in the interior of the two valves that required Emergency Services to isolate.
3. Sent to manufacturer to determine possible cause of failure.
4. Report back from manufacturer, All three valves seats damaged from “chatter.” “Chatter” is caused by:
   1. >10% pressure in the outlet when the valve goes off.
   2. Pressure drop in the inlet of the valve.
   3. If the relief valve is oversized for the application.



Results of Testing & Investigation

- By using a calibrated gauge on the system during testing we were able to:
  - Confirm all pressure switches and transducers functioned as designed.
  - Existing gauges on the system were within margin of error of the gauges.
  - Temperature did not effect the accuracy of compressor stop pressure.
  - Confirm that CNG acted more like a real gas vs. ideal gas.

Major Issues of the system to be determined

- Why the cylinders reached 5500 psi relief valve blow off settings
  - 42° F temperature increase from last refueling event,
  - Thermal Expansion of a real gas accounts for pressure > PRV set point
- Did the control system operate as designed prior to release.
  - Pressure Transducers/Switches operated system as designed
  - PRV's opened as designed.
- Did the pressure release system operate as designed.
  - PRV did not reseat after opening as designed;
  - PRV Vent Piping support system failure;
  - Design of PRV Vent Stack may not have prevented water accumulation.
- Why the 5500 psi relief valves acted as they did after operation
  - Forensic report of the three valves sent by manufacturer determined the valves suffered damage by "Chatter".

Draft Corrective Actions For CNG Plant

1. Reduce pressure set points on the two transducers on the Programmable Logic Controller in Building 522 that regulate when the two Compressed Natural Gas compressors shut off. The pressure settings shall be set from 4,500 psi to 4,200 psi.
Owner: **M. Kretschmann** Due Date: **Completed on 2/15/14**

2. Replace the three existing pressure relief valves with new valves. Valves will be the same model as the existing valves and designed to operate at 5,500 psi.
Owner: **M. Kretschmann** Due Date: **Completed on 2/15/14**

3. Design and install inlet and outlet pressure relief valve piping, fittings, and support system at Building 522 as approved by a New York State Licensed Professional Engineer.
Owner: **M. Kretschmann** Due Date: **8/4/14**

Draft Corrective Actions For CNG Plant

4. Design and configure transducers on the Programmable Logic Controller in Building 522 to initiate “High Pressure Alarm” at the Fire House High Pressure alarm to be set at 5,200 psi.
Owner: **M. Kretschmann** Due Date: **8/4/14**

5. Design and install pressure switches on each of Building 522’s CNG cylinders to initiate “High Pressure Alarm” at the Fire House High Pressure alarm to be set at 5,200 psi.
Owner: **M. Kretschmann** Due Date: **8/4/14**

6. Design, install, program and test Building 522 “High Pressure Alarm“ pressure switches to the Building’s Fire Alarm Panel and Site Fire Alarm System.
Owner: **M. Kretschmann** Due Date: **9/9/14**

7. Develop and Issue a procedure to reduce Compressed Natural Gas pressure at building 522 from a “High Pressure” condition of 5,200 psi down to 4,500 psi.
Owner: **H. Hauptman** Due Date: **9/9/14**

Draft Corrective Actions For CNG Plant

8. Issue a Lessons Learned (LL) Communication concerning the “Compressed Natural Gas Release” event at Brookhaven National Laboratory (BNL) to the BNL and DOE LL systems. Owner: **M. Gaffney** Due Date: **7/7/14**

9. Determine effectiveness of action # 7 by –conducting a walk through drill on the procedure to reduce Compressed Natural Gas during a “High Pressure” condition at Building 522. Owner: **M. Kretschmann** Due Date: **10/6/14**

Questions?